LOW VISION REHABILITATION

A Study Guide and Outline for
Ophthalmologists, Residents
and Allied Health Personnel

If you cannot cure the CAUSES,
take care of the CONSEQUENCES

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Medical practice must deal with a wide variety of health conditions that affect the lives of our patients. The usual medical focus is on acute care to fix the *causes* of these conditions; yet, in spite of the best and most timely medical and surgical interventions, chronic conditions and permanent impairments remain. Dealing with the *consequences* of these conditions is an integral part of medicine; it entails a focus that is different from that of acute care and is called **rehabilitation medicine**. Rehabilitation medicine is best known as physical rehabilitation, yet, it reaches across almost all medical specialties, including ophthalmology.

The various aspects of vision loss and their management are best discussed using the concepts defined in the WHO's *International Classification of Functioning (ICF, formerly known as ICIDH, the International Classification of Impairments, Disabilities and Handicaps)*. These concepts, which apply to any kind of functional loss (hearing, musculo-skeletal, etc.), are summarized in the following table.

ASPECTS of VISION LOSS

THE ORGAN		THE PERSON	
Disorder	Impairment	Ability loss for Activities	Handicap / Participation
Anatomical changes	Functional changes at the organ level	*Ability* to perform ADL *activities*	Social consequences
Examples: corneal scar, cataract, retinopathy, etc.	"visual functions" measured quantitatively *E.g: Visual Acuity, visual field, color vision*	"functional vision" described qualitatively *E.g.: Reading ability, mobility, daily living, etc.*	*Examples: Need for extra effort, loss of independence, job loss, etc.*

The first two columns refer to the organ; **disorder** refers to anatomical changes (such as cataract, retinal scar), **impairment** describes how each eye functions. We speak of **visual functions**, such as visual acuity, visual field, contrast sensitivity. etc. The next column describes how the person functions in terms of the **a*bility*** *to perform* ***Activities*** *of Daily Living (ADL).* The last column describes the social and economic consequences, formerly listed under the term **handicap**, now under the more neutral term **participation**. The various aspects are linked, but the links are not rigid. ***The art of rehabilitation is to influence these links, to maximize participation for any given disorder or impairment.***

The interventions needed to achieve this vary for the different links. Ophthalmologists must provide medical and surgical care to minimize the impairment caused by a certain disorder, but they have not been trained to effectively handle the right side of the table. For optometrists and visual aids specialists, the medical impairment is a given. They can reduce its disabling effect with various optical and non-optical devices. Educators, trainers and counselors must then take over to deal with the problems that may arise in various social settings, in the school, the home, the work place, etc. so that the social and economic disadvantages of the remaining ability loss are minimized.

Disorder	Impairment	Ability loss (Dis-ability)	Handicap
Anatomical changes	Functional changes at the organ level	Loss of *ability* to perform ADL *activities*	Social consequences

/\ /\ /\ Medical, surgical care — /\ /\ /\ Visual aids, devices — /\ /\ /\ Education, training

The client is not adequately served if any of these interventions are skipped. Since it is clear that no single individual can be expected to provide the whole spectrum of services, successful Rehabilitation must be based on **teamwork** between different professionals.

The challenge for Low Vision Rehabilitation is to provide effective teamwork between the medical and the educational professions. In the past this has not always been available, since most eye care (glasses, contact lenses) requires virtually no training, while totally blind persons require minimal eye care. The patient with Low Vision clearly needs the whole spectrum of services.

While the history of care for the blind goes back at least seven centuries to 1260 when the *Hôpital des Quinze-Vingts* was established in Paris to take care of soldiers blinded as hostages in the crusades, Low Vision care is very much younger. It is only half a century ago that the idea that sight could be 'saved' by not using it started to be abandoned. It is only two decades ago that the World Health Organization threw out the old black-and-white dichotomy between those who are 'legally sighted' and those who are 'legally blind' by defining ranges of vision loss and by replacing the old category of **'Blindness'** with a new one: **'Blindness and Low Vision'**. These ranges also became a part of ICD-9-CM, the official U.S. Health Care classification.

TERMINOLOGY: Blindness / Low Vision / Vision Loss

That it has taken such a long time for the Low Vision domain to be properly recognized is also due in part to the ingrained use of the term 'Legal Blindness' to denote severe vision loss. Use of the term 'Blindness' has an adverse effect on patients with residual vision. To call a person with severe vision loss 'legally blind' is as preposterous as calling a person with a severe heart ailment 'legally dead'. *The term 'Blindness' should be avoided by all who deal with patients and clients with Low Vision.* The term **Blindness** should be used only for those who are totally blind or whose residual vision is of marginal use. They must rely in *vision substitution* skills. The term **Low Vision** refers to those who are not blind *(hence the word Vision)*, but whose vision is less than normal *(hence the word Low)*. The term **Vision Loss** is a general term, which includes blindness as well as Low Vision and can be used with modifiers from mild to moderate, to severe, profound and total loss. It is blatantly untrue that Macular Degeneration is a 'major cause of blindness'; it is a 'major cause of Vision Loss'.

Many agencies are now modifying their name by dropping the word blindness, or by mentioning the visually handicapped or visually impaired. The WHO has changed the name of its major campaign from 'Prevention of Blindness' to 'Vision 2020, the Right to Sight..

Evaluation of Visual Performance

The *starting point* for any rehabilitation effort must be the accurate assessment of a patient's visual performance and visual potential. This is different from regular medical and surgical care, where visual function generally is a *measure of outcome*, rather than a starting point.

Our usual measurement techniques reflect this difference. Our usual charts are accurate between 20/15 and 20/100 (the normal and near-normal range), but beyond 20/100 there generally are only a few letters at 20/200 and 20/400. As an outcome measure for a medical or surgical intervention the difference between 20/200 or 20/400 is relatively unimportant, since both indicate a *'poor result'*. As a starting point for the prescription of visual aids the same difference is very important, since the patient with 20/400 needs twice as much magnification as the patient with 20/200.

We will discuss how this can be achieved.

Visual Acuity Measurement for Low Vision

Visual acuity notations are used so often that we tend to accept them as tokens denoting certain performance levels. It is important to consider their actual numerical meaning as well.

The 'acuity' (literally the 'sharpness') of vision denotes the ability to recognize small details. Snellen (1862) introduced the method of measuring visual acuity by using a letter chart with progressively smaller letters and defined its numerical value as a ratio comparing the patient's performance to a reference standard. For patients who need letters that are 2x closer or 2x larger, their magnification need is 2x and their visual acuity is 1/2. If the magnification need is 5x, visual acuity is 1/5, and so on. Usually these fractions are standardized to a numerator of 20, so 1/2 = 20/40, 1/5 = 20/100, etc. In this notation the numerator indicates the distance at which the patient can recognize the letter, the denominator indicates the distance at which a standard eye can do this.

To facilitate calculations, it is advantageous to adopt the metric system, as we do in all other areas of medicine. Louise Sloan (1959) made use of the metric system explicit by introducing the term ‘M-unit’ for a letter size subtending 5’ at 1 meter. Using M-units, Snellen’s formula is:

$$V = \frac{m}{M} = \frac{\textbf{viewing distance } \textit{(in meters)}}{\textbf{letter size } \textit{(in M-units)}}$$

We can state that:	**standard acuity**	(1.0, 20/20) represents the ability to
recognize a	**standard letter size**	(1 M-unit)
at a	**standard distance**	(1 meter).

Recognizing that **visual acuity** is defined as the reciprocal of the magnification need, makes it easier to utilize visual acuity numbers in Low Vision. The finding that a patient can read the 20/100 line as easily as a standard person can read the 20/20 line, means that the patient needs letters that are 5 times larger (or 5 times closer) to achieve standard performance. This relationship between visual acuity and magnification need is the basis for ‘Kestenbaum’s rule’, but is rarely referred to explicitly. *(See also Appendix II.)*

LETTER CHART at 1 METER

The common testing distance of 20 ft (6 meters) was chosen because it reduces the need for accommodation. However, the measurement range is limited, because too many large letters make the chart unwieldy. For Low Vision a wide measurement range is more important and a simple Snellen fraction that is easily converted is useful. The simplest fraction is obtained when the numerator is “1”, i.e. when the measurement is made at 1 meter. When testing at 1 meter the Snellen denominator refers directly to the **magnification need**. Furthermore, bringing the chart from 6 meters to 1 meter increases the measurement range by a factor 6, so that the entire Low Vision range can be covered. *See the Table on page 9.*

We recommend a **printed chart** with external illumination, since a printed chart in a lighted room is a more appropriate predictor of everyday function, than a projector chart in a dark or semi-dark room. In principle any chart could be used; we recommend a chart that is designed for this purpose and comes with a 1-meter cord attached.

A ready-made chart with a string and occluder attached is available from: Precision Vision, 944 1st Street, LaSalle, IL 61301, 815-223-2022. The chart folds to fit in an attaché case and follows the standard layout with five letters per line. Letter sizes range from 50 M to 1 M (1/50 = 20/1000 to1/1 = 20/20). The back side contains reading segments. A diopter ruler is included also.

Using a letter chart at <u>one meter</u> has significant advantages:

- It extends the measurable range down to 1/50 (20/1000) and makes more letters per line available at each level.
- It is easy to maintain the exact testing distance by extending the one-meter long string to the patient's forehead.
- The chart is within arm's reach of the examiner, who does not have to get up to point to the chart.
- One meter is 1 diopter from optical infinity; thus, a refraction carried out at this distance simply needs 1 diopter subtracted for distance correction; conversely, a 1 diopter lens placed over the distance glasses will focus the patient for 1 meter testing. This can be done with a trial lens in a Halberg clip or by placing a pair of +1D drugstore reading glasses over the patient's own correction.
- The resulting Snellen fraction (1/...) is easily converted to other notations. The familiar 20/20 notation is obtained by multiplying numerator and denominator by 20.
- The denominator indicates the **magnification need**, i.e. the minimum reading add in diopters needed for reading of 1M print (Kestenbaum's rule).

PRACTICAL HINTS:

Do not push patients too far for marginal performance, nor help by pointing to each individual letter. Traditional visual acuity testing often pushes for threshold performance. For Low Vision, we want to determine the magnification *need for functional reading. Therefore, we want to determine the level at which patients can perform with reasonable comfort using their own fixation ability.*

For occasional use and portability, the chart with the 1-meter string and occluder attached, may be hand held. Ask the patient to hold the occluder to one eye, stretch the string, and the chart will automatically be at 1 meter. For more frequent use a movable easel is helpful. Use the 1-meter string to adjust the distance of the easel when the patient leans forward.

READING PERFORMANCE at variable distances

Since reading is the endpoint most desired by low vision patients, using a reading card with continuous text is more informative than testing near vision on a reduced letter card. Letter recognition requires only a very limited retinal area; word recognition requires a larger area and fluent reading requires the availability of additional areas to the right of fixation to guide successive saccades.

Traditionally, reading vision is often tested at a predetermined, fixed distance. For low vision patients this reading distance may not be appropriate or the patient's current correction may not be optimal for the standard test distance. Therefore, a method is needed that allows simple calculations **applicable for any reading distance**. Such a method will be described.

As with distance acuity, two values are needed to calculate near visual acuity: *letter size* and *reading distance*. Many practitioners are in the habit of recording just the letter size read (e.g.: 'J7') without specifying the reading distance. This is a description of an ADL skill, but for Low Vision calculations such notations are meaningless. The ability to read newsprint at 5" is very different from the ability to do so at 15" or 20". Again, adopting metric measurements makes calculations possible. *(See also Appendix I.)*

Letter sizes should be expressed in **M-units**. This is the only unit that applies to both near and distance testing. Alternatives are printer’s points and Jaeger numbers. Printer’s points apply differently for different type styles and cannot be used to relate lower case text on reading cards to upper case letters on acuity charts. Jaeger’s numbers are item numbers that refer to the printer’s catalogue from which Jaeger selected his reading samples in 1854. They have no numerical meaning and are often used inconsistently on different cards.

The **reading distance** is best measured in **diopters.** While this may seem unfamiliar at first, it greatly facilitates calculations, since it changes the Snellen fraction to a multiplication. The term diopter indicates the reciprocal of a metric distance; it was introduced by Monoyer (1872) to simplify lens formulas. It can be used equally well for the reciprocal of any other metric distance.

$$\textbf{Magnification need} = \frac{1}{\text{visual acuity}} = \frac{\mathbf{1}}{\mathbf{V}} = \frac{M}{m} = M \times \frac{1}{m} = \mathbf{M \times D}$$

A ruler calibrated for this purpose is part of any phoropter and of the 1-meter Low Vision chart. *(See also Appendix I.)*

Thus, the recommended procedure is as follows:

(1) Determine the baseline performance with existing glasses:

- ask the patient to hold the reading material at whatever distance is in best focus with their existing glasses;
- measure the reading distance in diopters (using a phoropter type ruler);
- record the smallest letter size read (in M-units) as well as the reading distance (in diopters, D).
- Multiply M x D to confirm the consistency of the recorded findings. M x D should equal 1/V (the letter size read at 1 meter).

(2) If the patient cannot read the desired print size, provide more add:

- measure the reading acuity with more add *(adds do not stop at +3)*.
- adjust the reading distance as the add increases.

(3) For each reading add and reading distance two checks are made:

- check the reading distance vs. the reading add.

The reading distance in diopters should equal the dioptric power of the reading add. If the reading distance is different, encourage the patient to move the print until it is in best focus. With high adds it is impossible to estimate the correctness of the reading distance without an actual measurement.

- record M and D and compare M x D to 1/V.

If MxD equals 1/V we know that the visual acuity values are consistent. The common idea that near visual acuity and distance acuity are very different is merely based on poor measurement of performance at near.

(4) Continue until 1M (newsprint) is reached.

In a perfect case, the patient should have progressed from xM at 1D (1 meter) to 1M at xD. This is known as Kestenbaum's rule: the number of diopters needed to read newsprint is the reciprocal of the visual acuity value.

- when newsprint can just be read, try a little more add.

This will reduce the reading distance but increase the magnification and may improve reading fluency. Different patients will value this trade-off differently. Remember that while letter chart acuity tends to determine a threshold level, reading must be performed at a functional level, that may be somewhat higher.

- while the patient is reading, note not only the end point, but also the quality of reading (fast, slow, smoothly, stop-and-go, guessing, etc.). This provides information about the quality of the pericentral field *(see below)*

(5) (Optional) Determine the optimal reading speed.

The back of the 1-meter chart has **reading segments of uniform length***.* Timing the time needed to read each segment can be helpful for two purposes.

- To determine the most effective magnification level. Start at large print, determine where the patient slows down. The last segment read at reasonable speed indicates the most effective magnification level.

Some patients will read slowly at all magnification levels. This may indicate the presence of multiple scattered scotomata. In this case magnification will not make them read much faster. Underlining to facilitate tracking may be more effective. Some patients have a small island of useful vision; they may read slower when the print is too large.

- To determine the relative benefits of different modes of magnification (e.g: glasses vs. handheld magnifiers vs. stand magnifiers).

Advantages of the Modified Snellen formula

In summary, the advantages of using the 'M-unit and Diopter' (MxD) notation while gradually reducing the reading distance and recording performance at each step, are:

- **Any reading distance can be used**; there is no need for a prior refraction to correct the patient for a 'standard' reading distance.
- It provides several checks on the **refractive correction**. If the reading add and reading distance (in diopters) coincide at each distance, the basic refraction (or at least its spherical equivalent) must be correct.
- It provides several checks on the **visual acuity**. Consistent results at each distance reassure us of their reliability. Inconsistencies should not be ignored; they provide additional information, which demands an explanation *(see below)*.
- The gradual progression encourages the patient with each paragraph read, even if 1M is not attainable.
- The gradual progression also eases the patient into the eventual short reading distance which might otherwise be resisted if the examiner jumps directly to the highest add, based on Kestenbaum's rule.

PRACTICAL HINTS:

***Discrepancies** in the above measurements provide additional information.*

- *A **constant difference** between reading distance and reading add indicates an undetected refractive error. This often is an effective way to detect index myopia in elderly patients without a time consuming subjective refraction.*
- *Failure of the patient to bring the reading material closer in accordance with the increasing adds may indicate resistance to a close reading distance. If the reading distance is incorrect, the image will not be focused properly and reading will not be optimal. Many patients need to be continually reminded about this. An incorrect reading distance is probably the most frequent reason why patients may report that stronger reading glasses which were effective in the office 'do not work' at home. A good strategy is to ask the patient to start by bringing the print too close, then moving it away to the point of best focus.*
- *It is useful to have the patient start to read at a large print size where they can read easily. This is more encouraging than moving directly to their level of failure. If patients can read the (very) large print quickly, it will waste very little time. If they cannot read with fluency at any print size, it provides additional diagnostic and prognostic information.*
- *Patients who read large print smoothly, then slow down at smaller sizes, can be expected to respond to magnification with better reading speed. Patients who read slowly at all letter sizes will not read small, magnified print any faster than large, unmagnified print, although they may find magnification less strenuous.*
- *This is often found in patients with scattered peri-central scotomata.*
- *Paradoxical performance, where reading large words and letters is harder than reading smaller ones, may result from the use of a small island of high resolution sandwiched between paracentral scotomata, a condition often seen with drusen and geographic atrophy. Such patients may report more problems with long words than with short ones, and frequently loose their place when reading; they have a narrow range of optimal magnification and are often particularly responsive to underlining to facilitate tracking.*
- *When older patients have suffered a minor stroke and also have a maculopathy, it is often easier to distinguish between the cognitive handicap of the stroke and the visual handicap of the maculopathy when they are reading larger print.*

Visual Field Evaluation for Low Vision

The Peripheral Field

For orientation and mobility, the peripheral field is most important. If formal visual field studies are available, *Goldmann* fields are generally more informative than static fields such as the *Humphrey*. Since orientation is mainly concerned with large objects, a simple *confrontation* field can often provide most of the needed information. It has the additional advantage of being a good demonstration for the patient and for attending family members.

PRACTICAL HINTS:

For demonstration purposes it is useful to have the core of a toilet paper roll at hand; this restricts the field to about 20°, the field limit for 'legal blindness'.

Patients with moderate tunnel vision may still be able to drive, but they should have additional fender-mounted rearview mirrors and a panoramic internal mirror.

Patients with profound tunnel vision (5° field) may benefit from a reverse Galilean telescope as a field expander, usually the 2.5x pocket model. Patients with wider fields usually find scanning easier than a reverse telescope.

In patients with hemianopia, one should be aware of spatial neglect. Spatial neglect can exist with or without hemianopia and vice versa. Patients with spatial neglect will not scan spontaneously to the non-seeing side; sometimes their performance can be improved with extensive training.

Patients with panretinal photocoagulation for diabetic retinopathy may still have a fair visual field for hand motions on confrontation testing, but the quality of that field is poor. They should be made aware of this deficit and its impact on peripheral awareness.

The Central Field

For reading, the perifoveal field is most important. The functional area must be large enough for word recognition (as opposed to letter recognition) and there must be enough area to the right of fixation to guide the next saccade. Most patients with a central scotoma develop a preferred locus below or to the right of the scotoma (retinally, above the lesion).

Evaluating the central and pericentral field poses special problems, since (1) the resolution of traditional perimetry is very course compared to the resolution used for reading and (2) steady fixation is hard to achieve in the presence of a central scotoma. Much has been learned about the central visual field from macular perimetry using a scanning laser ophthalmoscope (SLO).

Contrast Sensitivity

Contrast Sensitivity describes the ability to detect objects of low contrast. Like visual acuity it can be a sensitive but non-specific indicator for a variety of problems in the visual system. Low contrast sensitivity means that objects must have more than average contrast to be detectable. Often increased illumination can compensate in part for reduced contrast sensitivity.

A finding of reduced Contrast Sensitivity can often explain why patients with normal or near-normal letter chart acuity complain that their vision is not optimal. Reduced contrast sensitivity may be seen in patients with more generalized retinal involvement, such as drusen and geographic atrophy. Such patients often are extremely responsive to an improvement in illumination.

Measuring and documenting contrast sensitivity is important because:

- It is a sensitive test for the **early detection** of certain conditions; especially those that leave high contrast visual acuity unaffected (e.g.: optic neuropathies, glaucoma, diabetes) and provides a means for **follow up** of such conditions.
- In Low Vision Rehabilitation, poor low contrast vision will predict significant difficulties in **activities of daily living** (ADL) since many ADL activities depend more on recognition of larger objects (sometimes of low or intermediate contrast) than on recognition of small details of high contrast. Typical low contrast tasks include driving in rain or fog, walking down steps, pouring milk into a white cup, recognizing faces, etc. Magnification is a useful remedy if small details of high contrast cannot be seen (e.g. reading); magnification does not help if an object (large or small) is not visible because of reduced contrast. Recognizing patients with reduced contrast sensitivity is important, since better illumination and enhancement of contrast in the environment are often more helpful than magnification.

For use in Low Vision we have found the 'LEA Low Contrast Test' particularly useful, because it is designed for hand-held use at 1 meter. The LEA Symbols (square, circle, apple, house) can be used for adults as well as for small children. Like the standard acuity chart the test provides five symbols at each level; it can be scored by simply recording the number of symbols seen. It provides a simple demonstration of the effect of contrast sensitivity loss for the patient and for family members.

Similar approaches are used in the Pelli-Robson chart (a letter chart, not suitable for children) and in the Vistech chart. Both tests are on wall charts and not as practical for handheld use in low vision. The Vistech test uses gratings and provides some additional information by measuring 5 points along the contrast sensitivity curve.

A unique approach is provided by the SKILL test, which provides a high contrast, high luminance letter chart (black-on-white) on one side and a low contrast, low luminance chart (black-on-gray) on the other. A measurement is obtained by comparing the performance on both sides. Since the card measures a difference it can be used at any distance and does not require standardized illumination. The combination of low luminance and low contrast makes it especially sensitive for early detection of minor changes.

VISION ENHANCEMENT

Vision can be enhanced in various ways. When walking in the woods at night, a flashlight may enhance your vision by bringing the **illumination** to a level where rods can function. Similarly, patients with macular degeneration may benefit from extra light to bring marginally functional cells to a functional level, thus reducing the scotomatous areas, as can be demonstrated by SLO macular perimetry.

Picking up a delicate piece of art to examine its details, enlarges the retinal image to bring more details above the resolution threshold. **Approximation** is the simplest and most used form of vision enhancement, but presbyopic patients will need a strong **reading add** or a **magnifier** to keep the image in focus.

When looking at a distant panorama, bringing the objects closer is not an option. A **telescope** creates an enlarged virtual image of the distant objects.

When driving along a poorly maintained road at night, you may wish that the side and center markings were re-striped to enhance the **contrast**. Patients may benefit from writing with a black felt-tipped pen or from place mats that provide contrast between their plate and the table.

Low vision patients may use one or more of these methods. Which method is used will depend on the task. No single solution is appropriate for all tasks. We will begin with a discussion of reading tasks, since difficulty reading is the most common complaint in our reading-oriented society.

READING GLASSES

In the previous section a method was described to bring patients gradually to a reading distance where they can read newsprint (1M). According to Kestenbaum's rule this will be the reciprocal of the acuity value *(E.g.: if the acuity is 20/160 = 1/8, the reading distance will be 8D (12.5 cm, 5"))*. Sometimes the reading distance can be a little longer, because binocularity and comprehension of continuous text can help. Often, the best distance is a little closer; the extra magnification may make the difference between marginal reading and fluency.

Up to 3D or 4D (25 cm, 10")

At these distances binocularity can be maintained with ordinary bifocals. Progressive lenses are not recommended since they produce more distortion in the higher powers, and since searching for the best area of the lens while simultaneously searching for the best retinal area to use may be difficult.

6D to 10D (15 - 10 cm, 6" - 4")

At these distances convergence is strained. Binocularity is maintained more easily when base-in prism is added. Ready-made half-eye glasses are available in powers of 6D, 8D and 10D (with 8, 10 and 12 diopters of prism OU). Sometimes the range is extended with 5D and with 12D. Half-eye glasses are recommended since they allow the patient to look up into the room.

The 6D half eyeglasses are often appreciated for small manual chores, be it writing, needle craft or clipping nails Experience shows that six inches is the closest comfortable distance for such activities, even if the patient needs much more magnification for reading..

10D to 20D (10 -5 cm, 4" -2")

Closer than 10 cm (4") binocularity cannot be maintained, even with prism. If this level of magnification is needed, reading must be monocular. For some patients the other eye needs to be occluded, but often this is not necessary and not even desirable. Leaving patients with no correction or with distance correction for the lesser eye, provides them with orientation vision when looking up from the reading task and greatly reduces the sense of nausea they might otherwise experience with strong lenses.

A prescription of +12 OD/plano OS will leave OS 12D out of focus for near, while OD is 12D out of focus for far; this makes suppression easier. Remember to write +12/plano rather than +12/balance, since the optician might make +12/+12, which will put both eyes in focus for reading, but looking at different columns, and will preclude distance vision.

A +20D reading lens is often well tolerated by young patients, but not by the elderly, who may have difficulty maintaining the exact reading distance.

Over 20D (closer than 5 cm, 2")

At this distance, maintaining the correct focal distance is very difficult. The attention given to the focusing task may distract from text comprehension. An elegant solution is the use of a spectacle mounted stand magnifier (e.g. Peak 10x). The base of this magnifier keeps the material in focus and frees attention for the reading task. Thus, even elderly patients can use magnification in the 30D range, provided that you explain the reason for the 'weird' appearance.

Advantages of reading glasses

1. Frees the hands
2. Wide field of view
3. Greater reading speed for continuous text
4. Binocular vision, up to 10D
5. Cosmetically acceptable

Disadvantages of reading glasses

1. Close reading distance
   uncomfortable for some
   may obstruct illumination
2. Not convenient for spot reading (labels, price tags)
3. Too close for writing, if over 6D

MAGNIFIERS

The optics of magnifiers are most easily understood by separating the optics of the eye (with distance correction, if needed) from the optics of the magnifier and the magnified object. If the object is at the focal point of the magnifier, parallel rays emerge from the magnifier; if the eye is properly corrected, it is set up to receive parallel incoming rays. In this situation the distance between eye and magnifier is irrelevant (parallel rays remain parallel at any distance) but the lens-to-paper distance must be tightly controlled.

If the object is slightly within the focal distance (which is usual) the rays emerge with a slight vergence and the eye must be set for these rays, i.e. focused at a finite distance. Most stand magnifiers are designed this way and, therefore, should be used with reading glasses. Exact optical calculations become more complex in this situation, but the basic statement remains true: that there is great leeway in varying the eye-to-lens distance and little leeway for the lens-to-paper distance. A high-plus spectacle lens is like a magnifier lens held close to the eye; hence the paper must be close.

The magnifier forms a virtual image of the page, which is located behind the page, usually at a finite distance. As the magnifier and page are moved farther from the eye, so is the virtual image that is seen by the eye. This means that a magnifying lens away from the eye is less effective than the same lens in the spectacle plane. Furthermore, if the text is within the focal distance (as it usually is), the magnifying effect is reduced further (a lens laid flat on the paper has little magnifying effect). It follows that the best magnifier will have to be somewhat stronger than the spectacle lens that provided the best reading performance. E.g.: if a patient ends up with a +10D reading lens, there is no use in trying a +5 magnifier for the same task, rather try +12 or +16.

Low power magnifiers (3D, 4D, 5D)

Low power magnifiers have the advantage that they can have a large diameter. For arts and crafts and viewing pictures a round magnifier may be preferred; for reading and writing a rectangular one can save some weight.

The usual +4 or +5 rectangular reader is wider than the patient's PD and thus allows binocular vision.

Magnifiers in this range are sometimes mounted on a movable arm with built-in illumination. This mode of illumination is an advantage since it avoids reflections on the surface of the lens. This type of magnifier is especially useful for hands free operation as for arts and crafts; reading will require movements of the head or of the book to span a wider page.

Medium power magnifiers (8D to 20D)

These magnifiers need to be of smaller diameter to avoid peripheral distortions. A strongly curved +8 magnifier can still allow binocular vision, but flatter magnifiers and higher powers require monocular vision, like their spectacle lens counter parts. An aspheric design may reduce distortion and thus allow a wider field. Some magnifiers have unequal curvatures on front and back. If the lens is close to the eye, the strongest curvature should be away from the eye (as it is in spectacle lenses). If the lens is close to the paper, the strongest curvature should be towards the eye (the Visolett, half dome magnifier is the extreme example). If the lens is held about halfway between the eye and the paper, the curvatures should be equal (as in the usual +5 rectangular magnifier).

As the power increases, the depth of field decreases and the need for accurate focusing increases. This is where stand magnifiers have an advantage, especially for patients with a tremor, with arthritis or with other problems that prevent them from holding and moving a magnifier for a prolonged period of time. Stand magnifiers provide more stability, but hand held magnifiers generally provide easier scanning.

High power magnifiers (over 20D)

For these powers a stand design is almost mandatory. As the power increases, the field of view decreases. Most must be held close to the eye where the field of view is largest.

Advantages of hand magnifiers

1. Longer, more customary reading distance
2. Familiar device, low patient resistance
3. Handy for spot reading (price tags, a recipe while cooking)
4. Generally cheaper than glasses

Disadvantages of hand magnifiers

1. One hand must hold the magnifier
2. Prolonged reading is slow and tiresome
3. Reduced effectiveness when the lens is too close to the text
4. Requires some dexterity, and absence of tremors

Advantages of stand magnifiers

1. Greater stability, less dexterity required
2. Focusing is automatic, magnification is constant
3. Can be very strong
4. Available with built-in illumination

Disadvantages of stand magnifiers

1. Bulkier, less convenient to carry
2. Narrow field of view; stand may interfere with external illumination
3. Awkward on curved or irregular surfaces
4. Not good for writing

ILLUMINATION

Some patients (albinism, aniridia, rod-monochromats) benefit from reduced illumination. Most patients (macular degeneration) benefit from more light.

A halogen torchiere lamp is an inexpensive way to raise the light level in an entire room. It may add usable hours to the day of many elderly patients.

A 50W halogen reflector bulb in an adjustable lamp can provide useful task lighting; these bulbs are far more effective than non-halogen reflector bulbs. Since they have a standard base, they can fit into any existing lamp. Since they illuminate a broader area, they are often preferred over more specialized point light sources.

Illuminated magnifiers

Some hand and many stand magnifiers are available with built-in light sources. There are several trade-offs that have to be considered.

All magnifiers with built-in illumination are heavier than their counterparts that rely on external illumination. The weight may be a problem for some patients.

Battery powered light sources are most portable, but they are heavier and batteries run out. A transformer can provide lasting power, but requires the proximity of an outlet. 120V sources are only practical for the larger magnifiers on a movable arm.

Halogen bulbs are available for many stand magnifiers. Since they drain batteries faster, they are best used with a transformer. LCD bulbs are the latest addition; they provide a high light level at moderate power consumption.

Most illuminated stand magnifiers have a closed white base. This base reflects the light and makes battery light more effective and even. At the same time it precludes the use of an external light source when the batteries run out. Some have an open base, but this requires a stronger bulb.

FILTERS

Yellow and **orange** filters are often useful for contrast enhancement as well as glare reduction, mainly indoors.

Gray, **amber** or other dark colors are helpful to reduce glare outdoors. A gray filter gives less color distortion; amber filters enhance the subjective brightness. Ask the patient to try both; half of them will prefer gray, the other half will prefer amber.

Slip-in and clip-on filters are inexpensive and avoid the need to carry two pairs of glasses. Prescription sunglasses have better optical quality (often not that important for low vision patients) and cost more; they generally do not protect against glare from the side. To protect against side glare use slip-ins that curve around or wrap-around goggles that fit over existing glasses. They come in a wide variety of tints.

TELESCOPES

The devices discussed so far are single lens devices for use at close range. For magnification at a longer distance a compound system of two or more lenses separated in space is required. This is called a telescope. Since all telescopes have lenses separated in space, they must have a tubular design, which must limit their field of view. They are also relatively expensive.

Traditional telescopes, field glasses or opera glasses, are made to focus only at longer distances, generally no closer than 20 ft. They are generally for binocular use with the tubes mounted parallel. In recent years, close focus telescopes have been developed which can focus from infinity to as close as 1 ft. These telescopes are monocular, for several reasons: it reduces cost and bulk, and many low vision patients have one eye that is much better than the other. Furthermore, for binocular near vision the tubes must be angled, as in surgical loupes. This angle defines the working distance, so that focusing at different distances is not possible.

Small telescopes can be mounted in spectacles for hands free use. However, since most telescope use is intermittent, such as for spotting a street sign, the use of hand held pocket telescopes is more common.

For magnification at more than arm length, telescopes are the only option.

Within arm's range spectacle mounted telescopes focused for near can provide hands free operation but only in a restricted field of view.

Due to the optical design, telescopes limit the amount of light that enters the eye, unless the front lenses are very large (as in night vision telescopes for the Navy). This can be a problem, especially for patients with reduced contrast sensitivity.

CONTRAST

All patients benefit from improved contrast, but some are more sensitive than others. A convenient hand-held test is the LEA Low Contrast Chart. The amount of contrast available in the environment cannot always be controlled. For most tasks improved illumination can compensate for a lack of contrast. Newspapers are often harder to read than magazines, because they have less contrast. However, on a glossy magazine page reflected glare may overwhelm the better contrast. These examples demonstrate that as much attention should be paid to creating a good reading environment as to the selection of the appropriate glasses or magnifier.

In many home activities contrast can be controlled. E.g.: do not pour milk in a white cup. Some people use a dark cutting board to cut white bread and a light one to cut a dark roast. If you have gray hair, it is hard to see against a white bathroom wall; reposition the mirror, so that you have a dark area behind you. Paint a white line or use bright tape at the top of steps that have poor contrast.

VIDEO-MAGNIFIERS

Since the mid-70s video magnifiers have found a lasting place among magnification tools. The basic **desk model** consists of a stand supporting a video camera with zoom lens and a video screen to display the magnified image; the text is moved on an X-Y table under the stationary camera. An alternative is a **hand-held camera**, which is moved across stationary text. This requires a little more dexterity.

The **advantages** include:

1. Maximized contrast and the option of reversed contrast, which is advantageous for some patients.
2. Binocular viewing at high magnification.
3. Postural comfort, since a constant reading distance is not required. Some patients may read more words per minute with glasses or a magnifier, but they can last more hours per day with a video magnifier.
4. A larger field of view than with comparable optical magnification.
5. Allows writing at high levels of magnification.
6. Adjustable magnification for different tasks, and a magnification reserve if deterioration is possible.

Disadvantages include:

1. Not portable.
2. Price.
3. Some training required.

Advances in video technology have allowed the development of smaller **hand held cameras**. They can be considerably cheaper because they connect to a standard TV set. Most lack the easy zoom ability of the standard video magnifier and require more dexterity to follow along a line because they lack the X-Y-table. A battery-powered camera with a battery powered TV screen can provide a portable unit, which may be important for a student who must move between different campus locations.

Most recently, the use of head mounted displays is becoming more practical. The best units are those that provide several camera options to be combined with several displays options.

The following table provides a summary of the points discussed in this section.

ICD-9-CM (WHO / ICO) CLASSIFICATION		VISUAL ACUITY VALUES				READING DISTANCES and *READING AIDS*
		Decimal notation	US notation	1-m chart	Magn need	
(Near-) Normal Vision	Range of Normal Vision	1.5 1.2 1.0 0.8	20/12 20/15 20/20 20/25	1/0.6 1/0.8 1/1 1/1.25	0.6 0.8 1 1.25	Reading distance 16" to 30" *Regular bifocals (up to 3 D)*
	Near-Normal Vision	0.6 0.5 0.4 0.3	20/30 20/40 20/50 20/60	1/1.5 1/2 1/2.5 1/3	1.5 2 2.5 3	Reading distance 8" to 12" *Stronger bifocals (4-5D)* *Low power magnifier (5D)*
Low Vision	Moderate Low Vision	0.25 0.20 0.15 0.12	20/80 20/100 20/120 20/150	1/4 1/5 1/6 1/8	4 5 6 8	Reading distance 4" to 6" *Half-eye glasses (6-10D)* *(with prisms for binocularity)* *Stronger magnifiers (10D)*
	Severe Low Vision	0.10 0.08 0.06 0.05	20/200 20/250 20/300 20/400	1/10 1/12 1/15 1/20	10 12 15 20	Reading distance 2" to 3" (cannot be binocular) *Hi-power reading lens (12 to 20D)* *Hi-power (stand) magnifiers (20D)*
	Profound Low Vision	0.04 0.03 0.025 0.02	20/500 20/600 20/800 20/1000	1/25 1/30 1/40 1/50	25 30 40 50	Reading distance 1" *Stand magnifier (40D and up)* *Video-magnifier* *Cane, O+M training*
(Near-) Blind-ness	Near-Blindness	0.015 0.012 0.010 0.008	20/1200 20/1500 20/2000 20/2500	1/60 1/80 1/100 1/125	60 80 100 125	*Video-magnifier* *Talking books, braille* *Voice output devices* *Cane, O+M training*
	Total Blindness	NLP				*Voice output devices* *Cane, O+M training*

HINTS FOR DAILY LIVING ACTIVITIES

Optical aids as discussed in the preceding section are important tools for reading and writing, but life is about more than reading and writing alone. We should never forget the vast area of life that is referred to as 'Daily Living Skills'. Most people spend more time doing these things than they do reading and writing. If you have access to a rehabilitation service with Occupational Therapists, or to Rehabilitation teachers through the Department of Vocational Rehabilitation or through an agency, you have a most valuable resource for your patients, which should not be ignored.

The following section gives a brief overview of many adaptations that can be used to provide better performance in the daily living skills area.

Reading/work environment: Glare free, adjustable light, halogen reflector bulb. Comfortable chair with arm support, good posture; copy or book-holder, clipboard, 'bean bag' lap table, desk or table.

Reading: Eccentric viewing, speed-reading techniques.
Tracking, underlining, window (typoscope) to isolate lines of text, hold material at different angle, R/L border marker.

Writing: Felt-tip pens, bold-line stationary, large-print checks, writing guides, templates for signature, envelopes.

Sewing, knitting, embroidery, crocheting, crafts:
Sewing machine: magnifier, needle-threader; hand sewing: large-eyed needles,
needle-threader; colorful knitting needles.

Optical Aids for crafts and chores: +6 half-eyes, chest supported magnifier, illuminated stand magnifier (even if too weak for reading).

Recognizing people: Tell friends and acquaintances about problem. Recognize friends by voice, body type, hairstyle, clothes.

Dialing phone: Large-print dial, large-print phone, memory phone, operator assistance.

Telling time: Change watch hands to black ones, low vision watch, talking watch / talking time (alarm), large-print wall or bedside clock.

Mobility: Assessment by mobility instructor, instruction if needed, sighted guide technique (for spouse, family and significant others).
White cane (long = sensing, short = support, identification).
Scanning eye movements to reduce blind spots.

Street signs, bus numbers: pocket telescope, ask someone.

Driving: Limited license for familiar area. Handicapped parking.

Shopping: Non-busy hours, call ahead to request help, volunteer.

Distinguishing coins or paper money: Serrated vs. smooth edge, coin purse, folding different denominations, putting paper money in different wallet compartments.

Housework, laundry: Counselor / teacher services, adaptation of dials, house-keeper, attendant / aide, grid-patterns.

Cooking: Large-print recipes, adaptation of oven and microwave dials, pouring and measuring techniques, timer, and counselor/teacher services.

Make-up, nails, podiatry care: Magnifying mirror, manicures, Big Eye or chest magnifier, friends or relatives, College of Podiatry.

Eating: contrasting food / dishes / table cloth, lean over plate a bit, clock method for identification. Feel weight of utensil, resistance, use bread, cracker as a pusher.

Taking Medications: Pill-splitter, pill dispenser; shape, color, rubber bands on bottles, family/friends to fill dispenser.

Board / table games, sports: Adapted games, large-print playing cards

Television: Sit close. 12" screen at 1ft. is larger than 25" at 4 ft.

Music: Large-print music, reproduce on enlarging copier, copyholder. Use more memorization.

Gardening: Pot vs. plot, tactile sense

COMMUNITY RESOURCES

Job-related: State Dept. of Rehabilitation

School-related: Dept. of Special Education, Disabled Students Union, Enabler programs.

Personal or family adjustment:
Explanation of benefits ('legal blindness'), resources, public / private agencies, transportation, etc.
Individual or family counseling. Support groups, peer support (often at local agency), community resources, service clubs (Lions), volunteers, homemaker aid.

Local Contacts: Look in Yellow Pages under 'Blind' and 'Visual Impairment'.

NATIONAL CONTACTS:

The Lighthouse Inc.
111 East 59th Street
New York, NY 10022
Low Vision Service
National Center for Vision and Aging
Phone: 212-821-9200

American Foundation for the Blind (AFB)
15 W. 16th Street
New York, NY 10011
E-mail: afbinfo @ afb.org
Phone: 800-232-5463

Council of Citizens with Low Vision
1850 Washington Ave.
Clearwater, FL 33755-1862
Phone: 800-733-2258

American Council for the Blind (ACB)
1010 Vermont Ave., NW – Suite 1100
Washington, DC 20005
Phone: 800-424-8666

National Federation of the Blind (NFB)
1800 Johnson Street
Baltimore, MD 21230
Phone: 410-659-9314

American Diabetes Association (ADA)
1660 Duke Street, P.O. Box 25757
Alexandria, VA 22314
Phone: 800-342-2383

American Printing House for the Blind
1839 Frankfort Ave. Phone: 502-895-2405 or 800-223-1839
Louisville, KY 40206

Association for **E**ducation and **R**ehabilitation of the Blind and Visually Impaired
4600 Duke Street – Suite 439 Phone:
Alexandria, VA 22304 E-mail: aernet @ laser.net

Library of Congress – National Library Service for the Blind and Physically Handicapped
1291 Taylor Street, NW Phone: 202-707-5100 or 800-424-8567
Washington, DC 20542

National Association of Parents of the Visually Impaired (NAPVI)
P.O. Box 317 Phone: 800-562-6265
Watertown, MA 02272

National Association for the Visually Handicapped (NAVH)
22 West 21st Street Phone: 212-889-3141
New York, NY 10010

RP Foundation Fighting Blindness
1401 Mt. Royal Avenue
Baltimore, MD 21217

REFERENCES:

1. **Low Vision Rehabilitation: Caring for the whole person.** Ophthalmology Monograph Series, # 12 American Academy of Ophthalmology (1999)
2. **Vision Rehabilitation for Adults.** Preferred Practice Pattern, American Academy of Ophthalmology, 2001
3. Colenbrander, August and Donald C. Fletcher, **Low Vision Rehabilitation** Ophthalmology Clinics of North America, Vol. 7, Number 2, June 1994. W.B.Saunders Comp., Philadelphia.
4. Faye, Eleanor, **Clinical Low Vision.** Little Brown Company, Boston. Second Edition, 1985
5. Jose, Randall T., **Understanding Low Vision.** American Foundation for the Blind, NY. 1983
6. **Directory of Services for Blind and Visually Impaired Persons in the United States.** Online: www.afb.org American Foundation for the Blind, NY.
7. **Making Life more Livable** - Simple adaptations for the homes of blind and visually impaired older people. American Foundation for the Blind, NY.
8. **The Lighthouse Handbook on Vision Impairment and Vision Rehabilitation.** Oxford University Press, 2000
9. **www.Lighthouse.org** for courses, aids, publications.
10. **www.Precision-Vision.com** for letter charts and reading cards.

APPENDIX I

PRINT SIZE, READING DISTANCE, MAGNIFICATION NEED

The table on page 13 lists the magnification needs (1/visual acuity) resulting from various combinations of print size and reading distance. **Letter sizes** are listed in M-units (1 M-unit subtends 5' at 1 meter). Equivalents are given in points notation and original Jaeger numbers. **Reading distances** are given in cm and inches as well as diopters (reciprocal of the metric distance). The diopter value is the most useful for quick calculations based on the modified Snellen formula.

$$\textbf{Magnification need} = \frac{1}{\text{visual acuity}} = \frac{\mathbf{1}}{\mathbf{V}} = \frac{M}{m} = M \times \frac{1}{m} = \mathbf{M \times D}$$

NOTE: For **clinical recording**, the table uses **nominal**, rounded numbers, based on the 'preferred numbers' series (ISO standard #3). Each step represents the same ratio (4/5); after ten steps, the same numbers repeat with a shift in the decimal position. Any product or quotient of preferred numbers is also a preferred number. Therefore, the same acuity values repeat, as indicated by the diagonal bands.

For **design** purposes less rounded values should be used:
design values ((also used for statistical calculations):
0.8 **1.0** **1.25** **1.6** **2.0** **2.5** **3.15** **4.0** **5.0** **6.3** **8.0** **10.0** 12.5 etc.
nominal values:
0.8 1 **1.2** **1.5** 2 2.5 **3** 4 5 **6** 8 10 12 etc.

APPENDIX II

CALCULATING with VISUAL ACUITY VALUES

Sometimes questions arise that require calculations involving the three variables: **letter size**, **viewing distance** and **visual acuity.** If any two of these variables are know, the third one can be calculated. The nomogram at the end demonstrates several calculation methods. They all give the same result.

A. Graphical *Use the black markers (ignore the numbers).* Find the markers for two of the variables. Connect them with a straight line and find where this line intersects the third row of markers.

B. Division *Use (the upper part of) the gray scales.* For distances of <u>one meter or longer</u>, the <u>traditional Snellen formula</u> is most useful: **V = m / M** (where m = viewing distance in meters and M = letter size in M-units). This formula is most useful for distance vision in the <u>normal and near-normal range</u>.

C. Multiplication *Use (the lower part of) the gray scales.* For distances <u>shorter than one meter</u>, the <u>modified Snellen formula</u>: **1/V = M x D** is easier to use. Here, D is the viewing distance expressed in Diopters (the reciprocal of the distance in meters). Multiplying D by M (the letter size in M-units) gives the magnification need, i.e. the reciprocal of the visual acuity. This form of the formula is most useful for near-vision in the <u>Low Vision range</u>. When acuity (V) and viewing distance (m) have small, fractional values, their reciprocals (1/V = magnification need, and 1/m = distance expressed in Diopters) provide more manageable numbers.

D. Addition *Use the numbers in the black markers.* The marker number for letter size represents a *'letter size credit';* the marker number for viewing distance represents a *'distance credit'*. The sum of these credits represents the *'Acuity score'*, listed in the visual acuity markers. This score is useful for the graphical representation of visual acuity values and for statistical manipulations, such as averaging of visual acuity values.

Note that letter size and visual acuity values are on opposite sides of the nomogram. Any letter size can represent any visual acuity value, depending on the viewing distance. A visual acuity value, therefore, cannot be used to identify a letter size, a habit that, unfortunately, is all too common.

The calculations are based on the metric values (to the left of each set of markers); the values are rounded for clinical use. The gray scales represent the preferred notations for far and for near measurements. The non-metric scales (to the right of each set of markers) are given for comparison. The Jaeger numbers are approximations based on Jaeger's original print samples (1854); the "Jaeger" designations on current cards are unreliable and often vary from card to card. On average, current cards use somewhat larger typefaces than Jaeger did.

EXAMPLES of **Visual Acuity Calculations** using the **Nomogram**

Question: *A patient can read J#1 at 16"; what is the visual acuity?*
Procedure A Find the marker that corresponds to J#1; draw a line to the marker that corresponds to 16". Extend that line to the visual acuity column, to reach the marker that corresponds to 20/20.
Procedure B 16" corresponds to 0.4 m; J#1 corresponds to 0.4M. **V** = 0.4m / 0.4M = 1.0 (20/20).
Procedure C J#1 corresponds to 0.4M; 16" corresponds to 2.5D. **1/V** = 0.4M x 2.5D = 1.0. V = 20/20.
Procedure D Size credit for J#1 = '70', Distance credit for 16" = '30'. '70' + '30' = '100' (20/20)
Answer: *J#1 at 16" represents standard vision (1.0, 20/20).*

Question: *A patient with 20/200 visual acuity wants to read 1M print (newsprint); what is the longest possible reading distance?*
Procedure A Find the 20/200 marker; draw a line to the 1M marker. It intersects the center column at the 10 cm (4", 10D) marker.
Procedure B V = 20/200 = 1/10; **V** = 1/10 = ..?.. m / 1M → distance = 1/10 meter (10cm).
Procedure C V = 20/200 = 1/10; **1/V** = 10 = 1M x ..?.. D → distance = 10 Diopters (10 cm).
Procedure D Acuity Score = '50'; Size credit(1M) = '50'; '50' = '50' + ..?.. → Dist. credit = '0' (10 cm).
Answer: *A patient with 20/200 will need a 10 cm (4") reading distance and a 10 D add to read 1 M.*

Question: *I want to design a poster. What is the minimum print size, so that people with 20/40 acuity can read the text at 10 ft;?*
Procedure A Connect the markers at 20/40 and at 10 ft; extend the line towards the marker for 6 M.
Procedure B 20/40 = 0.5; 10 ft = 3 m; **V** = 0.5 = 3 m / ..?.. M → M = 6.
Procedure C 20/40 = 1/2; 1/V = 2; 10 ft = 3 m = 1/3 D; **1/V** = 2 = ..?.. M x 1/3D = 2 → M = 6.
Procedure D Acuity Score = '85'; Dist. credit(10 ft) = '75'; '85' = .?. + '75' → Size credit = '10' (6M).
Answer: *The required minimum letter size is 6 M (or 50 printer's points).*

Question: *A patient with 20/300 sits 12" from a videomagnifier screen; what is the required minimum letter size on the screen?*
Procedure A Connect the markers at 20/300 and at 12"; extend the line to find the marker for 5 M.
Procedure B 20/300 = 0.06 12" = 0.3 m **V** = 0.06 = 0.3 m / ..?.. M → M = 5.
Procedure C 20/300 = 1/15 1/V = 15 12" = 3 D **1/V** = 15 = ..?.. M x 3 D → M = 5.
Procedure D Acuity Score = '40' Dist. credit(12") = '25' '40' = .?. + 25' → Size credit = '15' (5M).
Answer: *The letters on the screen must be at least 5 M (7.5 mm, 5/16").*

Question: *On a chart designed for 10 ft a row is labeled as 20/100. What is the actual letter size?*
Procedure A Connect the markers at 20/100 and at 10 ft"; extend the line to find the marker for 16 M.
Procedures B and C are relatively awkward for this purpose.
Procedure D Acuity Score(20/100) = 65. Distance credit(10 ft) = 75. Size credit = 65 - 75= -10 (16M).
Answer: *The letter size is 16 M.*

Question: *A patient could read the line in the previous question when the chart is held at 2 m. What is the visual acuity?*
Procedure A Connect the markers at 20/100 and at 10 ft"; extend the line to find the marker for 16 M.
Draw a new line from here through the marker for 2 m, to find a visual acuity of 20/160.
Procedures B and C would have been simple if the letter size were known. V = m/M = 2/16 = 20/160
Procedure D The distance credit for 2 m (65) is 10 less then the credit for 10 ft (75). Subtract 10 from the listed acuity score for 20/100 (65) to find 20/160 at score 55 (65-10).
Answer: *At 2m the "20/100 at 10ft" line represents a visual acuity of 20/160.*

The last two examples demonstrate the difficulties that arise when a letter chart lists only the visual acuity value for a specific distance; when the distance changes, a complicated calculation is needed. If the actual letter size is listed (as it was on Snellen's original charts), a change in viewing distance causes only a change in the numerator of the Snellen fraction, since the denominator (letter size) is independent of the viewing distance.

APPENDIX I – **PRINT SIZE, READING DISTANCE and MAGNIFICATION NEED**

based on the Modified Snellen Formula **1 /V = M x D** for near vision

Letter Size	**Viewing Distance** (glasses to text, not valid for magnifiers)													ICD-9-CM
	5cm *2"* 20 D	6.3cm *2.5"* 16 D	8cm *3.2"* 12.5D	10cm *4"* 10 D	12.5cm *5"* 8 D	16cm *6.3"* 6.3 D	20cm *8"* 5 D	25cm *10"* 4 D	32cm *12.5"* 3.2 D	40cm *16"* 2.5 D	50cm *20"* 2 D		100 cm *40"* 1 D	
5p J# 3 **0.63M**	12.5 *1/12.5*	10 *1/10*	8 *1/8*	6.3 *1/6.3*	5 *1/5*	4 *1/4*	3.2 *1/3.2*	2.5 *1/2.5*	2 *1/2*	1.6 *1/1.6*	1.25 *1/1.25*		**0.63** ***1/0.63***	Normal range
63p J# 5 **0.8 M**	16 *1/16*	12.5 *1/12.5*	10 *1/10*	8 *1/8*	6.3 *1/6.3*	5 *1/5*	4 *1/4*	3.2 *1/3.2*	2.5 *1/2.5*	2 *1/2*	1.6 *1/1.6*		**0.8** ***1/0.8***	Normal range
8p J# 7 **1 M**	**20** *1/20*	**16** *1/16*	**12.5** *1/12.5*	**10** *1/10*	**8** *1/8*	**6.3** *1/6.3*	**5** *1/5*	**4** *1/4*	**3.2** *1/3.2*	**2.5** *1/2.5*	**2** *1/2*		**1** ***1/1***	Normal range
10p J# 10 **1.25M**	25 *1/25*	20 *1/20*	16 *1/16*	12.5 *1/12.5*	10 *1/10*	8 *1/8*	6.3 *1/6.3*	5 *1/5*	4 *1/4*	3.2 *1/3.2*	2.5 *1/2.5*		**1.25** ***1/1.25***	Normal range
12p J# 12 **1.6 M**	32 1/32	25 *1/25*	20 *1/20*	16 *1/16*	12.5 *1/12.5*	10 *1/10*	8 *1/8*	6.3 *1/6.3*	5 *1/5*	4 *1/4*	3.2 *1/3.2*		**1.6** ***1/1.6***	Near-normal
16p J# 13 **2 M**	40 *1/40*	32 1/32	25 *1/25*	20 *1/20*	16 *1/16*	12.5 *1/12.5*	10 *1/10*	8 *1/8*	6.3 *1/6.3*	5 *1/5*	4 *1/4*		**2** ***1/2***	Near-normal
20p J# 14 **2.5 M**	50 *1/50*	40 *1/40*	32 1/32	25 *1/25*	20 *1/20*	16 *1/16*	12.5 *1/12.5*	10 *1/10*	8 *1/8*	6.3 *1/6.3*	5 *1/5*		**2.5** ***1/2.5***	Near-normal
25p J# 15 **3.2 M**	63 *1/63*	50 *1/50*	40 *1/40*	32 1/32	25 *1/25*	20 *1/20*	16 *1/16*	12.5 *1/12.5*	10 *1/10*	8 *1/8*	6.3 *1/6.3*		**3.2** ***1/3.2***	Near-normal
32p J# 17 **4 M**	80 *1/80*	63 *1/63*	50 *1/50*	40 *1/40*	32 1/32	25 *1/25*	20 *1/20*	16 *1/16*	12.5 *1/12.5*	10 *1/10*	8 *1/8*		**4** ***1/4***	Moderate L.V.
40p J# -- **5 M**	100 1/100	80 *1/80*	63 *1/63*	50 *1/50*	40 *1/40*	32 1/32	25 *1/25*	20 *1/20*	16 *1/16*	12.5 *1/12.5*	10 *1/10*		**5** ***1/5***	Moderate L.V.
50p J# 18 **6.3 M**	125 1/125	100 1/100	80 *1/80*	63 *1/63*	50 *1/50*	40 *1/40*	32 1/32	25 *1/25*	20 *1/20*	16 *1/16*	12.5 *1/12.5*		**6.3** ***1/6.3***	Moderate L.V.
63p J# 19 **8 M**	160 1/160	125 1/125	100 1/100	80 *1/80*	63 *1/63*	50 *1/50*	40 *1/40*	32 1/32	25 *1/25*	20 *1/20*	16 *1/16*		**8** ***1/8***	Moderate L.V.
80p J# -- **10 M**	200 *1/200*	160 1/160	125 1/125	100 1/100	80 *1/80*	63 *1/63*	50 *1/50*	40 *1/40*	32 1/32	25 *1/25*	20 *1/20*		**10** ***1/10***	Vision
	Near-total Visual Acuity Loss						Profound Low Vision				Severe Low			

APPENDIX II – **NOMOGRAM for VISUAL ACUITY CALCULATIONS**

LETTER SIZE				VIEWING DISTANCE				VISUAL ACUITY				ICD
40 M	-30				80 m	145	250 ft	1/0.5	2.0	115	20/10	Range of Normal Vision
					60 m	140	200 ft					
30 M	-25		J#24	0.02 D	50 m	135	160 ft	1/0.6	1.6	110	20/12	
					40 m	130	120 ft					
25 M	-20		J#23		30 m	125	100 ft	1/0.8	1.2	105	20/16	
					25 m	120	80 ft					
20 M	-15		J#22	0.05 D	20 m	115	60 ft	**1/1**	**1.0**	**100**	**20/20**	
					16 m	110	50 ft					
16 M	-10		J#21		12 m	105	40 ft	1/1.2	0.8	95	20/25	
				0.10 D	10 m	100	30 ft					
12 M	-5	100 p	J#20		8 m	95	25 ft	1/1.6	0.6	90	20/30	Near-normal Vision
					6 m	90	20 ft					
10 M	0	80 p	---		5 m	85	16 ft	1/2	0.5	85	20/40	
				0.25 D	4 m	80	12 ft					
8 M	5	60 p	J#19		3 m	75	10 ft	1/2.5	0.4	80	20/50	
					2.5 m	70	8 ft					
6 M	10	50 p	J#18	0.5 D	2 m	65	6 ft	1/3	0.3	75	20/60	
					1.6 m	60	5 ft					
5 M	15	40 p	---		1.2 m	55	50”	1/4	0.25	70	20/80	Moderate Low Vision
				1 D	**1 m**	**50**	**40”**					
4 M	20	32 p	J#17		80 cm	45	30”	1/5	0.2	65	20/100	
			(16)		60 cm	40	25”					
3 M	25	24 p	J#15	2 D	50 cm	35	20”	1/6	0.16	60	20/120	
				2.5 D	40 cm	30	16”					
2.5 M	30	20 p	J#14	3 D	30 cm	25	12”	1/8	0.12	55	20/160	
				4 D	25 cm	20	10”					
2 M	35	16 p	J#13	5 D	20 cm	15	8”	1/10	0.1	50	20/200	Severe Low Vision
				6 D	16 cm	10	6”					
1.6 M	40	12 p	J#12	8 D	12 cm	5	5”	1/12	0.08	45	20/250	
			(11)	10 D	10 cm	0	4“					
1.2 M	45	10 p	J#10	12 D	8 cm	-5	3“	1/16	0.06	40	20/300	
			(8,9)	15 D	6 cm	-10	2.5”					
1 M	**50**	**8 p**	**J# 7**	20 D	5 cm	-15	2”	1/20	0.05	35	20/400	
			(6)	25 D	4 cm	-20	1.6”					
0.8 M	55	6 p	J# 5	30 D	3 cm	-25	1.2”	1/25	0.04	30	20/500	Profound Low Vision
			(4)	40 D	2.5 cm	-30	1”					
0.6 M	60	5 p	J# 3	50 D	2 cm	-35	0.8”	1/30	0.03	25	20/600	
				60 D	1.6 cm	-40	0.6”					
0.5 M	65	4 p	J# 2	80 D	1.2 cm	-45	0.5”	1/40	0.025	20	20/800	
				100 D	1 cm	-50	0.4”					
0.4 M	70	3 p	J# 1	125 D	0.8 cm	-55	0.3”	1/50	0.02	15	20/1000	

Formulas used:

1/M	**X**	**m**	**= m / M =**	**V**	(visual acuity)	(B)
M	**X**	**D**	**= M x 1/m =**	**1/V**	(magnification need)	(C)
Size credit	**+**	Distance credit	**=**	Acuity score		(D)

See text for discussion and explanation.